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Title: iHiFi Project/Task LANL Lower S-Band Telemetry Transmitter Design
Re-use, Heritage, Pros/Cons

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iHiFi Project/Task

LANL Lower S-Band Telemetry Transmitter

Design Re-use, Heritage, Pros/Cons

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March 23, 2016

iHiFi: S-Band Telemetry Transmitter



- **ISR Division Electrical Engineering Capabilities**
 - Over 50 year of satellite electronics design
 - Near earth to deep space sensors
 - Multi-disciplinary designs
 - Expertise in advanced packaging for harsh environments
 - Radiation, thermal, vacuum & partial pressure, extreme shock and vibe
 - Large sensor hosted payloads –to- agile-space cubesats
 - End-to-end custom electronics and packaging
 - Receivers/Transmitters/Antennas
 - RF to microwave, classical to software defined
 - Custom airborne and terrestrial electronics hardware
 - Transmitters/Receivers with advanced digital modulation/encoding circuitry - xQPSK to Spread Spectrum
 - Portable ground stations and all ground support equipment

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Slide 2

iHiFi: S-Band Telemetry Transmitter

- **ISR Projects Being Leveraged for Design Re-use and Heritage**
 - “RoadRunner Gen3”
 - Terrestrial system containing the classical In-phase/Quadrature (I/Q) modulator/up-converter topology and transmit signal chain
 - Dual transmitter, dual frequency, lower S-band design at 10Watts transmit
 - Extensive design reuse - circuit topology, PCB footprint, and modulator/up-converter part selection
 - Flexible FPGA + DAC-based modulation core easily adaptable to OQPSK/SOQPSK or other modulation schemes
 - Design fits seamlessly with a telemetry acquisition front-end
 - Minimizes overall telemetry –to- RF circuitry/signal chain size, weight, and power through shared FPGA resources and integrated packaging
 - Final transmit power achieved through OEM driver/power amp (PA)
 - Reduced design risk + flexibility in final transmit power spec
 - Separates the small-signal chain from the high heat dissipation PA electronics for thermal design
 - Baseline iHiFi telemetry transmitter will follow this same OEM PA model while custom PA models and designs are being explored

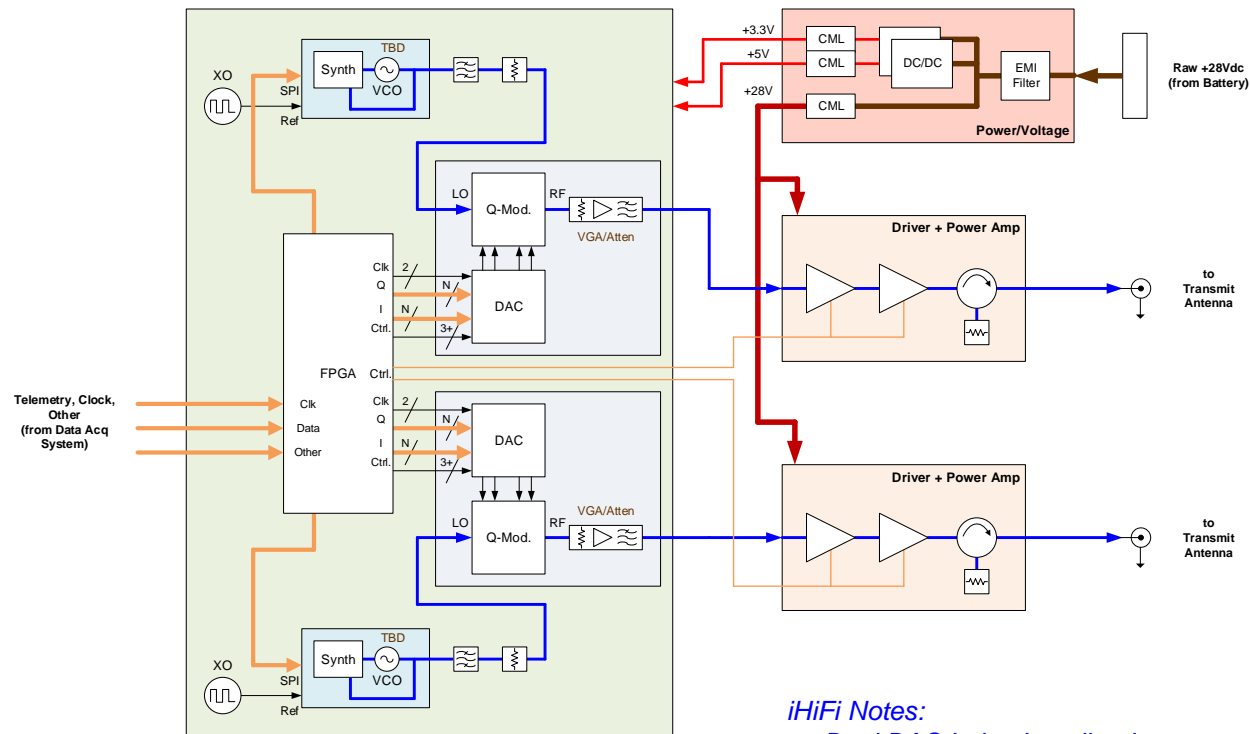
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Slide 3

iHiFi: S-Band Telemetry Transmitter

Preliminary

- **RoadRunner Gen3 Modulator/Up-Converter + DC + Power**
 - Functional block diagram being translated to iHiFi



iHiFi Notes:

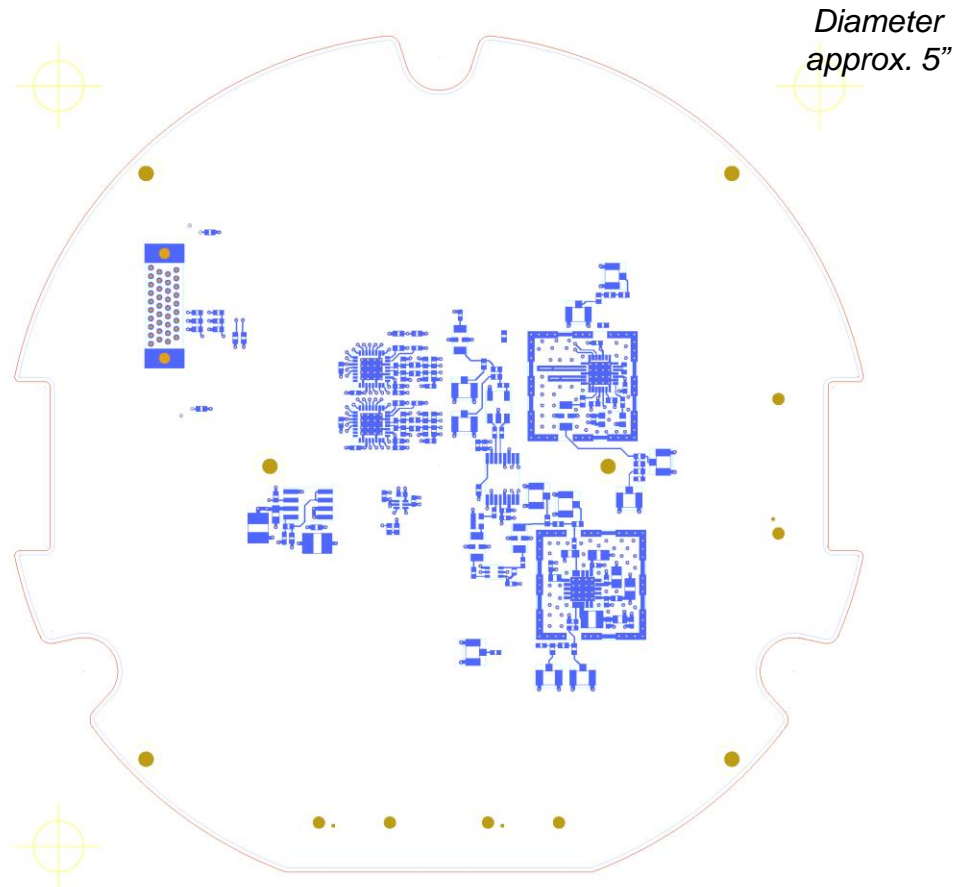
- Dual DAC being baselined
- FPGA is shared resource with core telemetry acq system

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Slide 4

iHiFi: S-Band Telemetry Transmitter

- **RoadRunner Gen3 Modulator/Up-Converter**
 - Initial Placement on iHiFi RF PCB Outline



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Slide 5

iHiFi: S-Band Telemetry Transmitter

- **ISR Projects Being Leveraged for Design Re-use and Heritage (cont.)**
 - Cubesat/Agile-Space "Prometheus II & III"
 - Two generations of Low Earth Orbit (LEO) electronics (again) containing the classical In-phase/Quadrature (I/Q) modulator/up-converter topology and transmit signal chain
 - Dual transmit/receive, multi-frequency (L-Band & S-band) design
 - Size, weight, and power optimized battery-based cubesat (1U)
 - Current generation design was used for initial circuit board "real-estate" data point
 - Has since been revised as iHiFi conceptual design has matured
 - Remaining circuitry being leveraged for parts with LEO flight heritage and in-house qualification test records
 - Driver stages to transmit chain (specific part numbers)
 - RF Digital –to- Analog Converter (DAC) (common vendor family/process)
 - I/Q Modulator (common vendor family/process)
 - Prometheus FPGA firmware ("code") and experience will be tapped for filtering/encoding foundation
 - Should yield substantial risk reduction and accelerate implementation

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Slide 6

iHiFi: S-Band Telemetry Transmitter

- **Thoughts Going Forward – Pros/Cons/Risks**

- Based upon heritage designs, the ISR Team has a high level of confidence that we can deliver prototype and flight hardware to execute the telemetry transmitter function being considered under the iHiFi Project
 - A conceptual design baseline is in place that leverages heritage electronic parts/circuitry, PCB layout, FPGA firmware, and many years of harsh environment electronics design, packaging, and integration experience
 - The size, weight and power challenges are recognized and manageable especially where the modulator/up-converter and driver amp circuitry is concerned
 - The higher-risk power amplifier design is manageable through an EOM approach that runs in parallel with a limited-scope custom in-house effort
 - Mil-Aero vendor sources for the PA have been identified and are being explored

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Slide 7

iHiFi: S-Band Telemetry Transmitter

- **Thoughts Going Forward – Pros/Cons/Risks (cont.)**
 - A fully integrated Telemetry System that encompasses “sensor data in” –to- “modulated RF out” is the path to the optimal size, weight and power solution
 - The system remains divisible into functional sub-elements but the packaging can be fine-tuned for highest density and ruggedness
 - One functional core instrument to qualify and test
 - Battery, power conversion subsystem, telemetry acquisition, modulation/up-conversion to RF
 - Leaves the final signal chain element and highest power/thermal load for optimization and risk reduction
 - Take advantage of OEM design expertise and flexibility to potentially optimize the PA efficiency or tailor the output power to meet minimum transmit power requirements

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Slide 8